VLBA Electronics Memo No. 6

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia 22903

January 16, 1984

MEMORANDUM:

TO: VLBA Electronics Group

FROM: M. Balister

SUBJECT: Cryogenics Reliability

I have gathered together some facts regarding reliability of 4.5K and 20K refrigerator systems in use at NRAO. These should give us some idea of expected reliability of the cryogenics associated with the VLBA project.

20K Systems

I have talked with Rudy Latasa and Jack Campbell and the picture here is fairly clear. The compressors (similar to the current CTI Model 1020R) are very reliable; MTBF ≃ 79,000 Hr!

The biggest problem results from seal wear on the 1020 refrigerator head which results in a slow temperature rise of the 20K cold station. The MTBF for these seals is ≃ 4,500 hours. Although seal replacement could be looked upon as regular maintenance and not a failure, it still represents the major loss of observing hours per antenna because of the long warm-up/cooldown time necessary for replacement.

For the VLBA project, we plan to use an almost identical compressor to the one in use at the VLA. Whether or not the seals on the Model 21/22 refrigerator which we plan to use for the VLBA will have similar problems is not known. There has not been a problem with seals, so far, on the three systems NRAO has at the moment. We plan a prolonged test of five systems shortly to gain some information on the long-term reliability of Model 22 refrigerators.

At the moment there is a feeling that minimizing the thermal load on the refrigerator well below its rated figures will significantly lengthen the time between required seal replacements.

4.5K Systems

Here I have talked with Chuck Brockway who has worked with the 5-26 GHz Cassegrain receiver on the 140' telescope for many years.

I have attached a breakdown of his problems over the last three years. Obviously, things have improved considerably over this period; however, seals still have to be replaced frequently. The 4K compressor does not seem to be anywhere close in reliability to the simpler 20K compressors in use at the VLA. The MTBF over the last year for the A receiver cryogenics system would appear to be ≃ 1,000 hours, which is within the limits given for DSN reliability obtained by A. Moffet (VLBA Electronics Memo No. 5).

Jack Campbell/Rudy Latasa have come up with a 1,500 hours estimate for the K-band maser cryogenic system at the VLA.

Conclusions

As far as the VLBA - the following conclusions can be drawn:

1. The two Model 1020R compressors we plan to use to drive the Model 22 refrigerator heads are essentially identical to the ones in use at the VLA. The good performance and reliability obtained with these units at the VLA and elsewhere is very encouraging. We should stick with this compressor type!

2. We have little experience with the 21/22 refrigerator; however, CTI now claims that the head MTBF has probably increased from 7,500 hours to 15,000 hours as a result of recent improvements. If this proves to be the case, this would be acceptable. We should start a long-term test of at least five units under varying load conditions to verify this claim. If this refrigerator has as serious seal problems as the 1020, we will find out fairly quickly running such a test.

3. If we plan to use 4.5K systems for the two higher frequencies, we should accept the fact that we will get lower reliability because (1) compressor is more complicated and less reliable than the current 1020R compressors and (2) failure due to He gas contamination is a major problem on some systems. Problems can certainly be worked on and reduced in magnitude; however, it may take a lot of manpower and system experience to get reliability close to the 20K system level.

   It is currently proposed that masers, if used, for the VLBA at 22 GHz and 43 GHz would be mounted on a single 4.5K refrigerator to save cost. This may be a mistake; it may make more sense to use separate refrigerators. However, this would result in a significant cost increase that is not covered by the current budget plan.

VLA CRYOGENICS RELIABILITY INFO

PERIOD NOV 1982 – OCT 1983

SUBSYSTEM (05) CRYOGENICS CASE STATISTICS:

MODULE NAME	CASES FOUND	MTBC DAYS	MTCR DAYS	REPAIR HOURS	% SUBSY	% VLA	OBSERV HOURS	% SUBSY	% VLA	% DOWN
CRYO-REF	53	185.9	6.9	115.3	96.81	89.94	645.1	98.76	93.96	.27
CRYO-COMP	3	3285.0	121.7	1.8	1.51	1.40	4.2	.64	.61	.00
VAC-PUMP	2	4927.5	182.5	2.0	1.68	1.56	3.9	.60	.57	.00
SUBSYSTEM	58	849.6	6.3	119.1	100.00	92.90	653.2	100.00	95.14	.28

MODULE NAME = Hardware module name
CASES FOUND = Number of reports found per module.
MTBC DAYS = Mean Time Between Cases or the true mean time between failure for given single module.
MTCR DAYS = Mean Time Case Rate which is the failure rate based on the number of that particular module in the system.
REPAIR HOURS= Total repair time for the number of cases found for the module.
% SUBSY = % of repair time, for the entire subsystem, expended for repair of the module.
% VLA = % of repair time, for all subsystemsin the VLA, expended for repair of the module.
OBSERV HOURS= Total observing hours lost (in antenna hours) for the number of cases found for the module.
% SUBSY = % of observing hours lost for the entire subsystem due to this module.

% DOWN = % of downtime, defined by operational antennas, for this module.